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NEWSLETTER

of the

Hawaiian Botanical Society

c/o DEPARTMENT OF BOTANY
UNIVERSITY OF HAWAII
HONOLULU 14, HAWAII

Volume III
Number 2
April 1964

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THE LEEWARD HAWAIIAN ISLANDS

By Charles H. Lamoureux[1/]

The Leeward group is a chain of small islands extending for nearly 1300 miles toward the northwest from Kauai. The islands comprising the group consist of remnants of nine former high islands with a present total dry land area of about 6.7 square miles (Nihoa, Necker, French Frigate Shoal, Gardner Pinnacles, Laysan, Lisianski, Pearl and Hermes Reef, Midway, Kure). In addition there are some 18 banks and shoals, the remnants of still other islands, that project upward to less than 50 fathoms from the surface of the sea. The total area within the 100-fathom line is more than 5000 square miles (Bryan, 1954). The leeward Hawaiian Islands probably represent the remains of the oldest islands in the Hawaiian chain.

The Leeward Islands are of great scientific interest. They provide demonstrations of several stages in atoll ontogeny from volcanic remnants such as Nihoa and Necker to remnants with extensive reef development such as French Frigate Shoal and the true atolls such as Midway and Kure. These islands may well have been "stepping stones" in the dispersal of plants and animals throughout the north central Pacific and probably played a major role in the movement of ancestors of the species which today comprise the flora and fauna of the main group of the Hawaiian Islands.

The Leeward Islands are significant as nature preserves for the protection of rare plants, birds, and mammals (the Hawaiian seal). More importantly they can serve as reasonably accessible yet well-defined laboratories for the study of evolution in isolated populations. They also provide opportunities for studies of relatively simple ecosystems. Studies of such simple ecosystems can be expected to reveal principles which would apply to more complex ecosystems elsewhere, but which could be discovered only with difficulty in these more complex ecosystems.

Space does not permit a full discussion of the political history of each of the islands. Such information as well as detailed geographical information is available in Bryan's (1942) excellent book "American Polynesia and the Hawaiian Chain". In brief, all the Leeward Islands except Midway were eventually annexed to the Kingdom of Hawaii and thus became part of the Republic, Territory, and State of Hawaii.

During the early part of the 20th century feather hunters were having a serious effect on the bird populations of the Leeward Islands. In order to stop this President Theodore Roosevelt, in February, 1909, created the Hawaiian Islands Bird Reservation by Executive Order. This included all the Leeward Islands from Nihoa to Pearl and Hermes Reef. Kure was added to the reservation in April, 1909.

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The area set aside as the Hawaiian Islands Bird Reservation is today known as the Hawaiian Islands National Wildlife Refuge. While politically a part of the City and County of Honolulu, the Refuge is in federal ownership under the jurisdiction of the Bureau of Sport Fisheries and Wildlife, U. S. Fish and Wildlife Service, Department of the Interior. In accordance with an agreement between the State of Hawaii and the Department of the Interior, immediate administration is under the Director, Division of Fish and Game, Department of Land and Natural Resources, State of Hawaii. The funds for administration of the Refuge are provided the State by the Department of the Interior.

In the following paragraphs the current status of botanical knowledge for each of the Leeward Islands is summarized:

NIHOA: Nihoa, also called Moku Manu or Bird Island, is closest to the main group of any of the Leeward islands, and is located about 120 miles northwest of Niihau. The island is basaltic, a remnant of a high island and reaches a maximum elevation of 895 feet. It has an area of 156 acres. The east, north, and west sides of the island are steep, high cliffs; the south side slopes rather gently toward the sea, and divided into six valleys with intervening ridges. The Tanager Expedition, which made the only botanical survey of the island, found 20 species of vascular plants on Nihoa. Of these four species (Pritchardia remota, Amaranthus brownii, Portulaca caumii, and Schiedea verticillata) were endemic to Nihoa.

The most conspicuous elements of the vegetation were the Pritchardia palms, which occurred in groves in two of the valleys. The ridges were generally covered with Eragrostis variabilis and Panicum torridum, while the valleys were covered with a dense growth of shrubs including Chenopodium oahuense, Sida sp., Solanum nelsoni and Sesbania tomentosa. There have been no complete botanical surveys of Nihoa since the Tanager Expedition, but in 1962 wildlife biologists from the Hawaii Division of Fish and Game collected 11 species of plants there, all of which were represented in earlier collections. Since there has been no military construction on the island, and very few visitors, it is probable that the flora has changed very little since 1923.

NECKER. Necker Island, about 150 miles west of Nihoa, is also a ridge of volcanic rock. It is somewhat smaller than Nihoa, reaching a maximum elevation of 276 feet, and has an area of 41 acres. On this small island, which today appears barren and inhospitable, archaeologists have discovered evidence of an archaic Hawaiian culture, including stone images of a type not found elsewhere in Hawaii. Apparently both Nihoa and Necker were inhabited by the early Polynesian settlers of Hawaii. The Tanager Expedition found only five species of vascular plants living on Nihoa in 1923, (Panicum torridum, Chenopodium oahuense, Sesuvium portulacastum, Portulaca lutea, Sesbania tomentosa). Seven additional species were planted in 1923, but none of these species were found in 1924. There has been no botanical work on Nihoa since 1924.

FRENCH FRIGATE SHOAL: French Frigate Shoal, about 480 miles northwest of Honolulu, is a crescent-shaped atoll on which are a number of sand islets. A few miles to the southwest are two rock islets, the larger of which La Perouse Rock is 122 feet high. The total land area is about 50 acres. The Tanager expedition found six species of vascular plants scattered among eight of the sand islets. The other sand islets and the rocks were devoid of higher plants. Tern Island, near the northern end of the atoll, is the only island where extensive botanical collections have been made since 1923. Tern Island is the site of an airstrip, probably constructed during or just after World War II, and of a loran station.

In 1923 Lepturus repens, Chenopodium oahuense, Boerhavia diffusa, Portulaca lutea, and Tribulus cistoides were found on the island (Christophersen & Caum , 1931). During construction of the air strip the entire island was subjected to bulldozing and clearing. In 1948 Dr. Vernon E. Smith visited the island and did not find any higher plants growing there. By October 1953 revegetation had progressed to the point where H. I. Rainwater was able to collect 9 species, and in February 1956 A. Svihla collected 7 species and reported four others (Svihla, 1957). In September 1961 Lamoureux found 22 species of vascular plants. Six of these were obviously cultivated species, five

were species which were part of the original vegetation of the islet, one (Scaevola taccada) was probably intentionally introduced but could be a native species, and 10 species were weeds which were probably introduced unintentionally along with the cultivated plants. These weedy species form the dominant aspect of the present vegetation (Lamoureux, 1961).

GARDNER PINNACLES: Gardner Pinnacles consist of two barren rocks located 108 miles northwest of French Frigate Shoals. The larger of these rocks was about 170 feet high but reports indicate that the top of the island was blasted away in recent years to create a helicopter landing pad. The pinnacles represent the westernmost island in the chain with exposed volcanic rock. In 1923 Gerrit Wilder collected a Portulaca on Gardner, but the specimen was lost and the only existing record of a vascular plant from the islands is the duplicate field label he prepared (Christophersen & Caum, 1931).

LAYSAN: Laysan Island, located about 200 miles northwest of Gardner Pinnacles and 790 miles northwest of Honolulu is a low coral island about one and three quarter miles in length and one mile wide. Most of its surface is composed of coral sand with patches of coral reef and beachrock near the shore. The island is used as a nesting area by various sea birds and large deposits of guano were found there in earlier times. The center of the island is occupied by a lake, the water in which is about twice as saline as "typical" sea water. The west, north, and east rims of the island reach heights of 30 to 40 feet before sloping downward toward the central lake, but the south rim is only about 10 feet above sea level.

Laysan is probably the best known and most thoroughly studied of the Leeward Islands. It has long interested naturalists, not only as a major breeding ground for sea birds, but as the home of five endemic birds and five endemic plants. In 1892 guano digging operations were initiated on the island. In 1896-97 the German naturalist, Schauinsland, spent three months on Laysan. His paper (1899) provides us with a description of the island in a reasonably natural state, and indicates that the native vegetation contained about 25 species of higher plants. In 1903, just before guano digging ceased, rabbits were introduced to Laysan. The rabbits multiplied at an extremely rapid rate, and by the time the Tanager expedition visited Laysan in 1923 most of the plants and many of the birds had disappeared. With the disappearance of the plants the rabbit population became depleted by starvation. The Tanager expedition killed the remaining rabbits and planted seeds and cuttings of many plant species (Christophersen and Caum, 1931). Despite the almost complete destruction of the original vegetation, the island has become well revegetated. In September 1961 24 species of vascular plants were found on Laysan of which probably 16 were native (Lamoureux, 1963a, c). These 24 species occurred in five distinct associations:

1. Nama association. On beaches above high-water mark, extending inland from 10 to 300 meters. Dominated by Nama sandwicensis var. laysanicum, with Portulaca oleracea, Boerhavia diffusa, Ipomoea pes-caprae, and Heliotropium curassavicum.
2. Scaevola association. A band from 5 to 100 meters wide, inland of the Nama association. Also present in scattered patches on lower inner slopes of island, below the Eragrostis association. Dominated by Scaevola taccada with Ipomoea pes-caprae, Capparis sandwichiana, Boerhavia diffusa, Tribulus cistoides, and Eragrostis variabilis.
3. Eragrostis association. A band from 50 to 500 meters wide on the crest and inner slopes. Dominated by Eragrostis variabilis with Tribulus cistoides, Boerhavia diffusa, Nicotiana tabacum, and Fimbristylis cymosa.
4. Boerhavia-Tribulus-Ipomoea association. A band from 10 to 100 meters wide on inner slopes below the Eragrostis association. Dominated by Boerhavia diffusa, Tribulus cistoides, and Ipomoea pes-caprae, with scattered plants of Eragrostis variabilis, Sicyos sp., Pluchea indica, and Ipomoea indica.
5. Sesuvium-Cyperus-Heliotropium association. A band from 10 to 100 meters wide above the shore of the lake. Near the lake shore Sesuvium portulacastrum and Cyperus laevigatus occur in pure stands; further from the shore

both species occur together and mixed with Heliotropium curassavicum. Scattered plants of Ipomoea pes-caprae, Tribulus cistoides, and Fimbristylis cymosa are also found here.

Plans are being made to revisit Laysan periodically in order to study changes in the flora and vegetation which may occur.

LISIANSKI: Lisianski Island, about 115 miles west of Laysan, is also a low coral island. It is about a mile and a quarter long and three/quarters of a mile wide. The island is shaped generally like Laysan with a rim 10 to 40 feet high surrounding a central depression. On Lisianski this central depression is dry while on Laysan a salt lake is present in it.

The history of Lisianski is similar to that of Laysan, guano digging around the turn of the century, introduction of and multiplication of rabbits, destruction of vegetation, death of rabbits, recovery of vegetation. In contrast to Laysan, however, almost no botanical work has been done on Lisianski. In fact only four species of vascular plants are reported for Lisianski (Christophersen and Caum, 1931). Recent photographs I have seen show several other species to be present, but Lisianski remains the most poorly known, botanically, of all the Leeward Islands.

PEARL AND HERMES REEF: Pearl and Hermes Reef, about 110 nautical miles northwest of Honolulu, is an atoll about 17 by 10 miles in diameter. A variable number of sand islets are located on the south and east portions of the reef. About five of these islets are sufficiently stabilized that they support higher plants. The only botanical work on this atoll was conducted by the Tanager expedition, which collected some 11 species of vascular plants (Christophersen and Caum, 1931). Recent photographs suggest that additional species are now present, but verifying specimens are not available.

MIDWAY: Midway Islands is the official name of this atoll, located about 1150 nautical miles northwest of Honolulu. There are two major islands on the southern rim of the atoll, Sand and Eastern, and a variable number of small sand spits, some of which support a terrestrial vegetation.

The Atoll has been inhabited since the turn of the century, first by employees of the Commercial Pacific Cable Company, then by Pan-American Airways, and finally by the military, which controls it today.

According to Christophersen and Caum (1931) the natural vegetation of the atoll consisted of about 19 species of vascular plants. The inhabitants have attempted to introduce all sorts of ornamental and food plants to Midway, and at one time even brought it several hundred tons of topsoil from Honolulu to mix with the available coral sand. Along with the soil and desirable plants many noxious weeds have been introduced.

Reasonably complete records have been kept and observations have been published with some regularity (St. John, 1935; Hadden, 1941; Neff and DuMont, 1955; Bailey, 1956; Lamoureux, 1963b) so that we have a good idea of floristic and vegetational changes. Recent studies (unpublished) indicate that some 95 species of higher plants are now growing on Midway, by far the largest number of species on any of the Leeward Islands.

KURE: Kure Atoll, also known as Kure Island and Ocean Island, is the westernmost island of the Hawaiian chain, about 50 miles west of Midway. The atoll is some six miles in diameter. Green Island, the only permanently vegetated island is situated on the southeast corner of the reef. Two or three small sand spits are usually evident, and may occasionally support the growth of a few vascular plants. The earliest botanical account of Kure was provided by Christophersen and Caum (1931) who reported that 13 species of vascular plants were present. Clay (1961) visited the island in 1959, just before a program of "habitat improvement" designed to make the island more attractive to albatrosses was initiated. Clay found that even though there had been little disturbance of the island, six species of introduced plants had become established on the island.

In September 1961, two years after the "habitat improvement" for albatrosses, and six months after the Coast Guard constructed a Loran station on the island, I visited Kure. The survey made then (Lamoureux, 1961) indicated that while the thirteen original species were still present on the island an additional 28 species were recorded. It was too early at that time to predict the effect this new introductions would have on the original species, and follow-up studies should be made as soon as possible.

From the foregoing it is evident that even though a few of the Leeward Islands are relatively well known botanically, most are essentially unknown, and a considerable amount of work needs to be done. The major sorts of problems today are dynamic ones, and deal with the relationships between the native and introduced species on each island, the ability of certain native species to compete successfully with introduced species (and vice-versa), and the overall effects on the ecosystem of vegetational changes. Solutions to most of the problems require work not only in plant taxonomy and ecology, but also in physiology, morphology, microbiology, soils, and in related aspects of zoology. Many opportunities are available here. We should take advantage of them.

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MAY MEETING: The May meeting will convene on Monday, May 4, at 7:30 P.M. in Agee Hall, H.S.P.A. Experiment Station, Keeaumoku Street. The program will be presented by Dr. S. K. Majumder, Dept. of Horticulture, University of Hawaii. Dr. Majumder will speak on "Botanical Studies with Flourescence Techniques" and will illustrate his talk with color slides.

BOTANICAL NOTES

SCIENCE FAIR: The Hawaiian Botanical Society Prizes awarded at the 7th Hawaiian Science Fair are as follows: Senior Division, $15 wish award to Stephen Anthony Ferreira, Kauai High School, "Answers to the Papaya replant problem"; Intermediate Division, $10 wish award to Bessie Frantz and Christianne Friese, R. L. Stevenson Intermediate School, "The effects of poisonous plant juices on the growth of bacteria, Staphylococcus albus and Escherichia coli.". Judges were A. J. Bernatowicz and C. H. Lamoureux.

VISITORS: Mr. Terry Pennington of Oxford University visited the Bishop Museum, Foster Gardens, and the Department of Botany, University of Hawaii in early March. Mr. Pennington is a specialist in the Meliaceae and returns to Oxford for continued graduate study after field work in Malaya, Borneo, Australia, New Guinea, New Caledonia, and Fiji.

Dr. H. S. McKee of the C.S.I.R.O., Canberra, Australia, visited the Bishop Museum, Foster Gardens, and the Department of Horticulture, University of Hawaii, in March. Dr. McKee recently completed extensive field work in tropical America, specializing in collections of Legumes having potential agronomic value.

Professor and Mrs. Ernst Abbe, Department of Botany, University of Minnesota, visited the Department of Botany, University of Hawaii, enroute to Malaya where they will continue field studies of genera of the Fagaceae.

Dr. H. U. Stauffer of the Botanical Museum, University of Zurich, is visiting the Bishop Museum and Department of Botany, University of Hawaii, and is accomplishing field studies of Hawaiian representatives of Exocarpos and Santalum. He has studied populations on Oahu, Kauai, Maui, and Hawaii. His work in Hawaii completes field studies initiated in South Africa and continued in Australia, New Guinea, New Caledonia and Fiji.

DEPARTMENT OF HORTICULTURE: Mr. Warren Yee has just returned from Taiwan, Hong Kong, and Japan as a consultant to the Pan-Pacific Company to develop a Passion Fruit project in central Taiwan. He also studied banana production techniques in Taiwan for the University and brought back with him two heavy-bearing longan selections and 9 or 10 vegetable varieties for trial here.

Dr. Roman Romanowski attended the W-63 Western Regional Weed Control Project meetings in Logan, Utah, and presented a paper on "Chemical Weed Control with Horticultural Crops in Hawaii" at the Western Weed Control Conference in Salt Lake City.

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The HAWAIIAN BOTANICAL SOCIETY was founded in 1924 to "advance the science of Botany in all its applications, encourage research in Botany in all its phases," and "promote the welfare of its members and to develop the spirit of good fellowship and cooperation among them." "Any person interested in the plant life of the Hawaiian Islands is eligible for membership in this Society."

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The Hawaiian Botanical Society Newsletter is published in February, April, June, October, and December. It is distributed to all Society members and other interested individuals and institutions, with the purpose of informing them about botanical news and progress in Hawaii and the Pacific. News contributions and articles are welcomed. The deadline for submission of news items is the 20th of each month prior to publication.

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